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Somatic cell counts in raw ewes' milk in dairy practice: frequency of distribution and possible effect on milk yield and composition

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Abstract

The aim of the work was to analyse the somatic cell counts (SCC) of the individual sheep milk samples under practical conditions. Totally 2159 samples were collected from four farms in April, May, June and July. Ewes were divided into five SCC groups on the basis of individual SCC: Low = <200000 cells.mL^{-1}, Middle = between 200000-400000 cells.mL^{1}, Higher = between 400000-600000 cells.mL^{-1}, High = between 600000-1000000 cells.mL^{-1}, Mastitis = >1000000 cells.mL^{-1}). The percentage of distribution of individual milk samples in SCC groups was as followed: 71.79 %, 10.24 %, 5.05 %, 4.03 % and 8.89 % respectively. Thus 82.03 % of samples of whole data set were below 400000 cells.mL^{-1} and only 8.89 % over 1000000 cells.mL^{-1}. Lacaune had a higher percentage of milk samples in the group Mastitis as compared to the other breeds or crossbreds. Factor SCC group reduced the milk yield, while a significant difference was observed in ewes of Mastitis SCC group as compared with ewes in Low SCC group (419±13 mL, 503±6 mL, resp.). The high percentage of ewes in the first two SCC groups significantly contributes to the possible development of limits for sheep milk quality.

Key words: ewe's milk, somatic cell counts, milk yield, composition

Introduction

Breeding of sheep for multiple purposes (milk, wool and meat) has a long tradition in Slovakia. Therefore sheep breeding are currently the only livestock species whose number is stabilized in Slovakia (Gálik, 2016). At present more effort in sheep breeding is related to milk production. In Slovakia ewe's milk is mainly used for cheese making. Thus milk yield and milk quality is an important issue for sheep dairy practice. One of the mechanisms for improving the milk yield and milk composition is management of breeding. Important tools for good managements are keeping available information on individual production and health. However, in the past five years the number of animals included in milk recording decreased continuously (currently only about 14 % of ewes) (Ryba and Dianová, 2016), despite the observed tendency to increase the milk yield due to crossing with Lacaune and better management of breeding systems.

Regular milk recording in Slovakia is mainly based on the analysis of milk composition, with exceptional analysis for somatic cell counts (SCC) (Margetín et al., 2013). SCC is widely considered as an indicator of udder health (Green et al., 2004). At the present, neither individual nor bulk samples of sheep's milk are usually analysed for SCC since the milk payment according to SCC is not implemented. Such regulations rely to the insufficiently clarified objective factors and relationships affecting

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the milk SCC in terms of physiological and pathological aspects (Fragkou et al., 2014), despite the fact that it is known that SCC is related to the presence of microorganisms in the mammary gland and thus udder health (McDougall et al., 2002; Suarez et al., 2002). Subclinical mastitis negatively influences cheese yield and its quality (Silanikove et al., 2014).

In Slovakia only few work was done to examine the individual SCC in practical conditions (Margetin et al., 1995; Margetín et al., 2013; Tančin et al., 2015; Vršková et al., 2015). One large study was done by Tomáška et al. (2015) who performed the bulk milk analysis of 1086 samples collected from the March to August and revealed that only 7.3 % of samples were in category below 500000 cells mL^{-1}; while 49 % of bulk milk samples were above 1000000 cells mL^{-1}. Thus a more detail research of the main factors contributing to high level of bulk SCC in dairy practice in Slovakia is required. One of the main approaches is to measure the SCC in individual milk samples of ewes.

The aim of the work was to measure the SCC and composition of the individual sheep milk samples under practical conditions, and to examine the importance of individual SCC on bulk SCC. Possible effect of SCC on milk yield and composition as well as effect of months and farm (breed of ewes) was studied.

Material and methods

The study was performed at four dairy farms with differed breeds and crossbreds under Slovakian usual practical conditions (milking and pasture). At the first and fourth farm purebred Tsigai (TS) ewes twere kept, at the second farm there were crossbred Improved Valachian x Lacaune ewes (IV/LC, - with higher proportion of Improved Valachian), at third farm there were kept two groups of ewes - 3a (crossbred ewes of synthetic population of Slovak dairy ewe - SD), and 3b (purebred Lacaune ewes - LC). At all farms the ewes were on pasture during the day and housed in stable during the night. Twice a day the machine milking in parlour was performed, whereat all animals received concentrates in amounts of 200 g per day . There were different dairy parlours in involved farms - first and third 1x16, second 1x24, fourth 2x12.

The milking of ewes started shortly before Easter (suckling lambs were sold) and lambing of the most ewes were within 3 weeks (January/February). The milk yield recording and milk sampling were performed once a month during evening milking as a part of milk recording services. Milk samples (50 mL) were collected from the whole milk yield into the recording jar (ICAR approved). Table 1 contains data on months of milk collection and numbers of animals involved at studied farms.

Table 1. Numbers of experimental ewes on farms in each month

Farm	Month				
	April	May	June	July	Overall
Farm 1			222	195	417
Farm 2			479	473	952
Farm 3a	88	103	120	121	432
Farm 3b	15	25	31	31	102
Farm 4	61	66	65	64	256
Overall	164	194	917	884	2159

The basic milk composition was determined by MilkoScan FT120 (Foss, Hillerød, Denmark) and somatic cells count were determined using a Fossomatic 90 (Foss Electric, Hillerød, Denmark) after heat treatment at 40 °C for 15 min.

The percentage of milk samples distribution in different SCC groups was calculated within a farm and within a whole data set. The percentage of milk lost represented a volume of milk obtained from ewes with SCC over 1000000 cells mL^{-1} from whole milk obtained in bulk tank per milking.

Statistical analysis was performed by a SAS program (ver. 8.2; SAS Institute, 2001). The Somatic cells count was evaluated using logarithm values (log SCC). According to the individual SCC in milk of animals, the dairy ewes were divided into five SCC groups (SOMATIC) (Low = <200000 cells.mL^{-1}, Middle = between 200000-400000 cells.mL^{-1}, Higher = between 400000-600000 cells.mL^{-1}, High = between 600000-1000000 cells.mL^{-1}, Mastitis = >1000000 cells.mL^{-1}). The effect of months (MONTH) was evaluated according to the months of milk sampling (April, May, June and July). Effect of the farm was studied taking into account the breeds why 5 groups (farm third divided into two because of two groups of breeds) were involved (first, second, third with SD ewes - 3a and third with LC ewes - 3b, fourth). Data are presented as LSM (Least Squares Means) ± SE (Standard Error) per milking.

The used statistical model (mixed model methodology) can be written as follows:

$y_{ijnp} = \mu + SOMATIC_i + MONTH_j + FARM_n + u_p + e_{ijnp}$

y_{ijnp} = the measurements for milk yield and composition (fat, protein, lactose and log SCC)
μ = overall mean,
$SOMATIC_i$ = the fixed effects of SCC groups (i = 1 to 5),
$MONTH_j$ = fixed effect of months of sampling (j = 1 to 4),
$FARM_n$ = fixed effect of farms (n = 1 to 5),
u_p =random effect of ewes, $u_p \sim N(0, \sigma_u^2)$,
e_{ijnp} = random error, assuming $e_{ijn} \sim N(0, I\, \sigma_e^2)$.

The calculation of SCC in the bulk milk tank was evaluated by:

$$SCC_T = \frac{\sum_{j=1}^{n} SCC_j * MY_j}{\sum_{j=1}^{n} MY_j}$$

SCC_T - in bulk,
SCC_1, SCC_2, ... SCC_j - individual SCC at sampling day,
MY_1, MY_2, ... MY_j - individual milk yield per milking at sampling day

Table 2. Characteristics of statistical file of studied traits

Variable	N	Minimum	Maximum	LSM	SE
Milk yield, mL	2159	20	1400	384	4.47
SCC, 10^3 cells.mL^{-1}	2159	1	26741	509	41
log SCC	2159	3.00	7.43	4.91	0.02
Fat, %	2150	0.90	13.80	7.21	0.04
Proteins, %	2150	3.96	11.06	5.90	0.02
Lactose, %	2150	2.54	7.81	4.83	0.01

LSM - least square means, SE - standard error

Table 3. Calculated somatic cells count (10^3 cells mL^{-1}) in bullk milk tank with and without the "Mastitis" group of ewes and the possible lost of milk (%) in the "Mastitis" excluded from milk delivery

Farms	Month	SCC in bulk milk tanks, 10^3 cells.mL^{-1}			Lost Milk from "Mastitis" ewes, %
		with "Mastitis" ewes	without "Mastitis" ewes	Improvement, %	
Farm 1	June	289.63	140.52	51.48	7.71
	July	150.07	92.11	38.62	1.92
Farm 2	June	248.42	124.51	49.88	5.98
	July	126.24	63.75	49.50	3.79
Farm 3a	April	688.50	169.04	75.45	7.56
	May	518.48	169.29	67.35	5.74
	June	794.90	175.85	77.88	9.89
	July	916.88	204.26	77.72	13.56
Farm 3b	April	1392.04	285.90	79.46	38.97
	May	1056.77	160.98	84.77	24.43
	June	483.18	184.00	61.92	16.74
	July	1103.99	155.83	85.88	19.05
Farm 4	April	1292.22	304.41	76.44	15.47
	May	740.24	232.68	68.57	15.80
	June	843.62	251.97	70.13	16.33
	July	670.02	199.62	70.21	12.03
All farms	Total	484.21	146.34	69.78	8.73

Results and discussion

Table 2 contains the basic statistics of the studied traits.

Table 3 presents SCC in the bulk milk tank calculated on the base of individual SCC and the individual yield, if such milk would be mixed together. For all samples mixed together, the SCC reached a level of 480000±140000 cells mL^{-1} which is similar to average values in Table 2. If we consider the data of individual farms and months, only at the first two farms the means of SCC were below 500000 cells mL^{-1} as it was generally found out by Tomáška et al. (2015). Therefore the third column in Table 3 represents the calculated SCC in the bulk milk tank without individual ewes whose SCC was over 1000000 cells mL^{-1} (SCC group Mastitis). Discharging the milk from the ewes of Mastitis SCC group, asignificant reduction in SCC of the bulk milk tank was achieved, though there was a different effect on the reduction milk amount delivered to dairy or processed in farm as calculated from the actual milk yield in tank per milking (Table 3). It could be noted that reducing the number of animals with SCC over 1000000 cells mL^{-1} could be an effective way for reduce the SCC in the bulk milk tank. There was a high probability that high SCC (over 1000000 cells mL^{-1} or even more) was related to the presence of udder infection with minor or major pathogens (Suarez et al., 2002). Riggio et al. (2013) found that from the culture negative samples, 83.7 % had SCC <500000 cells mL^{-1} and 97.4 % had <1000000 cells mL^{-1}.

The results in Table 3 lead to a question related to the distribution of animals in different SCC groups especially of animals in the group over 1000000 cells mL^{-1}. On the basis of individual analysis of milk samples for SCC it was possible to distribute animals into five different SCC groups (Table 4). Out of the 2159 samples collected in total, 1550, 221, 109, 87 and 192 were divided in low, middle, higher, high and mastitis SCC groups respectively and thus it represents a percentage as followed: 71.79 %, 10.24 %, 5.05 %, 4.03 % and 8.89 % respectively. According to data in Table 4, most of the animals had SCC in milk below 400000 cells mL^{-1} (82.03 %). Which might be the most important finding of the presents research.The percentage was influenced by farms, season, purebreed or crossbreed origin. At the first two farms the percentage of ewes with SCC over 1000000 cells mL^{-1} was very low (Table 4) and the improvement of SCC in bulk milk tank without being milked was almost 50 % (Table 3), though loss of the discharged milk reduced slightly. The high percentage of ewes in Mastitis group at other farms and months (Table 4) increased the loss of the discharged milk dramatically (Table 3), if milk of ewes from Mastitis group would not be included.

Under the same management conditions at farm 3 there was possible to see the effect of breed (Table 4). LC had higher percentage of samples over 1000000 cells mL^{-1} as compared to SD and the highest if compared to other breeds/farms. The effect of farm management (farm 1 and 4) with the same breed (TS) was also an important factor (Table 4) contributing to the SCC in individual ewes. More detail study of differences in farm management at mentioned farms would be required, but it was not within the scope of our study.

The distribution of milk samples into different SCC groups revealed that more emphasis should be concentrated to the work with ewes showing over 1000000 cells mL^{-1}. Low percentage of animals with SCC over 1000000 cells mL^{-1} (whole dataset) could indicate subclinical health problems of the udder rather than physiological factors taking into account in small ruminants. Recently Kuchtik et al. (2017) reported very low level of SCC in milk of Lacaune ewes throughout lactation (range 36000-480000 cells mL^{-1}) too. Berthelot et al. (2006) reported healthy ewes with SCC below 500000 cells mL^{-1} and infected udders with SCC higher than 1000000 cells mL^{-1}. The literature reports a reduced individual SCC in ewes during past few years (Pengov, 2001; Berthelot et al., 2006; Arias et al., 2012). Riggio et al. (2013) stated that in uninfected Valle del Belice ewes, 83.7 % of the samples were in the category below 500000 cells mL^{-1} and only 2.6 % above 1000000 cells mL^{-1}. According to Prpić et al. (2016), in healthy 80 East Friesian ewes the SCC was low (log SCC±SE for ewes with singles and twins 5.11±0.03 and 4.95±003 respectively) but in infected ewes the SCC significantly increased (5.85±0.06 6.22±0.06 respectively). Though very low percentage of animals in Mastitis group was detected at some farms, one farm at which 40 % of animals were detected in Mastitis group also occurred. On farm level, the subclinical mastitis was detected at 15 to 40 % of the ewes (Kiossis et al., 2007; Contreras et al., 2007).

It is possible to point out that despite the effect related to months of year, farms or breeds (Table 4), most of the raw milk samples were in the first two or three SCC groups, why udder health appeared to be the most important factor affecting SCC. According to Suarez et al. (2002), Riggio et al. (2013) and Skapetas et al. (2017), as well as data of the present study, the individual SCC in raw milk of ewes could not be classified as a problem, if good management and effective mastitis control program were performed at sheep farms. This supports findings of Paape et al. (2007) who reported SCC in milk of ewes being similar to dairy cows.

Factor SCC group reduced milk yield but significant difference was observed in ewes of Mastitis SCC group in comparison to ewes in the Low SCC group (419±13 mL, 503±6 mL, resp.). Negative phenotypic correlation between SCC and milk production in different breeds was reported by several authors in Manchega ewes (Arias et al., 2012) and in Churra ewes (Gonzalo et al., 2002). Špánik et al. (1996) calculated the negative correlation between SCC and the milk yield. A significantly negative correlation between SCC and milk production in Tsigai ewes during both, suckling and milking period was also found by Margetin et al.

Table 4. Frequency of distribution (%) of milk ewes according to SCC groups in farms per months and per whole data set for all farms

Farm - Breed	Month	SCC group				
		Low	Middle	Higher	High	Mastitis
Farm 1 - TS	June	69.37	9.46	6.31	4.50	10.36
	July	84.62	3.59	5.64	4.10	2.05
Farm 2 - IV/LC	June	77.04	8.98	3.76	3.97	6.26
	July	87.74	3.81	2.54	2.11	3.81
Farm 3a - SD	April	69.32	10.23	5.68	3.41	11.36
	May	67.96	12.62	4.85	5.83	8.74
	June	67.50	14.17	3.33	5.00	10.00
	July	58.67	14.88	5.79	5.79	14.87
Farm 3b - LC	April	26.67	26.67	0.00	6.67	40.00
	May	52.00	8.00	12.00	0.00	28.00
	June	61.29	9.68	3.23	9.68	16.13
	July	51.61	25.81	0.00	0.00	22.58
Farm 4 - TS	April	29.51	29.51	13.11	9.84	18.03
	May	48.48	19.70	13.64	3.03	15.15
	June	38.46	26.15	10.77	4.62	20.00
	July	57.81	15.63	7.81	4.69	14.06
All farms*		71.79	10.24	5.05	4.03	8.89

*Percentage of samples distribution for all farms was calculatd as real number of samples in different SCC groups (sum of all farms and months) divided by whole number of samples*100.
Low = SCC<0.2×10^6 cells.mL^{-1}, Middle = SCC between 0.2-0.4 $\times 10^6$ cells.mL^{-1}
Higher = SCC between 0.4-0.6 $\times 10^6$ cells.mL^{-1}
High = SCC between 0.6-1 $\times 10^6$ cells.mL^{-1}, Mastitis = SCC > 1 x 10^6 cells.mL^{-1}
TS - Tsigai, IV - Improved Valachian, LC - Lacaune, SD - Slovak dairy ewe

Table 5. The effect of SCC groups on milk yield and milk composition

	SCC groups										
	Low		Middle		Higher		High		Mastitis		
Variable	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	P
Milk yield, mL	503^{a}	6.61	450^{bc}	12.33	455^{bc}	17.43	465^{ab}	19.45	419^{c}	13.22	<0.0001
Fat, %	6.32^{a}	0.058	6.29^{a}	0.093	5.95^{b}	0.123	6.18^{ab}	0.137	6.23^{a}	0.099	0.0298
Protein, %	5.6^{a}	0.028	5.61^{a}	0.045	5.44^{b}	0.06	5.56^{ab}	0.066	5.68^{a}	0.048	0.0117
Lactose, %	4.88^{a}	0.015	4.84^{ab}	0.024	4.76^{c}	0.032	4.78^{bc}	0.036	4.58^{d}	0.026	<0.0001

$^{a-d}$within row significantly different at P<0.05
see Table 4.

(1996). Though significant effect of SCC groups on fat and protein content (Table 5) was found in this study, the effect was not related to the increasing SCC groups as recently presented for higher protein and fat content in a group of ewes with high SCC (Vršková et al., 2015) or presented by de Olives et al. (2013). There was a negative effect of SCC on the lactose content (Table 5) which corresponded well to numerous previous studies (Bianchi et al., 2004; Olechnowicz et al., 2009; Mioč et al., 2009, Olives et al., 2013).

A significant effect of farm on milk yield, composition and log SCC could be obsereved, especially if the first farm was compared to the fourth farm where the same breed was raised (Table 6). Also the effect of the breed at the same farm (farm 3) could indicate that the risk for udder health problem increased along with increasing the milk production. Higher SCC was found in LC in comparison to the Manchega ewes (Rovai et al., 2014).

The months of milk sampling significantly influenced the observed traits (Table 7) as it was recently published by Skapetas et al. (2017). Because of the short lambing period, the months of milk sampling could be considered as an effect of advance stage of lactation. The milk yield, protein and fat content had similar progress as recently published for TS and IV breeds (Oravcová et al., 2015). According to Gonzalo et al. (1994), log SCC, fat and protein percentages increased along the lactation period by 31.2, 37.6, and 20.3 % respectively, which was not obsereved for log SCC in this study. Even in July the log SCC dramatically decreased. Similar reduction of SCC during lactation of crossbred ewes was published by Mioč et al. (2009).

Conclusion

According to the obtained results 82.03 % of the tested samples were below 400.000 cells mL^{-1} and only 8.89 % over 1000000 cells.mL^{-1} indicating a good status of udder health in tested animals. Lacaune had higher percentage of milk samples in group over 1000000 cells mL^{-1} as compared to other breeds or crossbreds. High percentage of ewes' milk samples in the first two SCC groups may contribute to the development of legislative limits for sheep milk quality as it is accepted for dairy cows.

Table 6. Milk yield, somatic cells count and milk composition in farms (breeds or crossbreds)

	Farms										
	First (TS)		Second (IV/LC)		Third (SD)		Third (LC)		Fourth (TS)		
Variable	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	P
Milk yield, mL	373^{a}	13.6	384^{a}	9.94	509^{b}	9.21	655^{c}	18	371^{a}	10.93	<0.0001
log SCC	4.45^{a}	0.056	4.55^{b}	0.041	5.23^{c}	0.039	5.47^{d}	0.071	5.39^{d}	0.052	<0.0001
Fat, %	5.92^{a}	0.105	6.55^{b}	0.081	5.86^{a}	0.074	5.54^{c}	0.123	7.11^{d}	0.091	<0.0001
Protein, %	5.73^{a}	0.051	5.86^{b}	0.039	5.13^{c}	0.036	5.1^{c}	0.059	6.09^{d}	0.044	<0.0001
Lactose, %	4.94^{a}	0.027	4.97^{a}	0.021	4.64^{b}	0.019	4.59^{b}	0.032	4.69^{c}	0.024	<0.0001

$^{a-d}$within row significantly different at P<0.05

Table 7. Influence of months on milk yield, SCC and milk composition

	Month								
	April		May		June		July		
Variable	LSM	SE	LSM	SE	LSM	SE	LSM	SE	P
Milk yield, mL	532^{a}	14.77	552^{a}	13.68	441^{b}	8.69	309^{c}	8.55	<0.0001
log SCC	5.12^{ab}	0.059	5.02^{a}	0.053	5.21^{b}	0.041	4.72^{c}	0.043	<0.0001
Fat, %	5.89^{a}	0.104	5.68^{a}	0.096	5.78^{a}	0.077	7.42^{b}	0.082	<0.0001
Protein, %	5.37^{a}	0.051	5.64^{b}	0.046	5.48^{c}	0.037	5.82^{d}	0.04	<0.0001
Lactose, %	4.87^{a}	0.027	4.74^{b}	0.025	4.84^{a}	0.02	4.62^{c}	0.021	<0.0001

$^{a-d}$within row significantly different at P<0.05

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Broj somatskih stanica u sirovom ovčjem mlijeku u mljekarskoj praksi: učestalost distribucije i mogući učinak na količinu i sastav mlijeka

Sažetak

Cilj rada bio je analizirati broj somatskih stanica (SCC) individualnih uzoraka ovčjeg mlijeka ovaca na farmama. Prikupljeno je ukupno 2159 uzoraka s četiri farme tijekom travnja, svibnja, lipnja i srpnja. Ovce su bile podijeljene u pet SCC skupina na temelju pojedinačnih SCC vrijednosti: niska = <200.000 stanica.mL^{-1}, srednja = između 200.000-400.000 stanica.mL^{-1}, viša = između 400.000-600.000 stanica.mL^{-1}, visoka = 600.000-1.000.000 stanica.mL^{-1}, mastitis = >1.000.000 stanica.mL^{-1}). Postotak distribucije pojedinačnih uzoraka mlijeka u SCC skupinama bio je kako slijedi: 71,79 %, 10,24 %, 5,05 %, 4,03 % i 8,89 %. Tako je 82,03 % svih ispitivanih uzoraka sadržavalo manje od 400.000 stanica mL^{-1}, a samo je 8,89 % sadržavalo više od 1.000.000 stanica mL^{-1}. Pasmina Lacaune imala je veći postotak uzoraka mlijeka u skupini "Mastitis" u usporedbi s ostalim pasminama ili križancima. Faktor SCC utjecao je na smanjenje prinosa mlijeka u skupini, dok je značajna razlika zabilježena kod ovaca svrstanih u "Mastitis SCC" skupinu (419 ±13 mL^{-1}) u usporedbi s ovcama u "Niska SCC" skupini (503 ± 6 mL). Visok postotak ovaca u prve dvije "SCC skupine" značajno pridonosi mogućem razvoju graničnih vrijednosti broja somatskih stanica za definiranje kvalitete ovčjeg mlijeka.

Ključne riječi: ovčje mlijeko, broj somatskih stanica, količina mlijeka, sastav

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